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A
DISCOURSE
OF
NAVIGATION;

Containing ſeveral
RULES *and* INSTRUCTIONS
TO BE
Obſerved in the Practice thereof:
AND
Shewing the uſe of two INSTRUMENTS,
lately invented, for reſolving
all *Triangles* and all *Problems*, in
SAILING, without any Operation
by *Arithmetick.*

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THE

PREFACE.

THE Advantages of Trafick and Commerce, are become the Concern of all Nations to promote and improve.

But Experience ſhews, that without the uſe of Navigation, whereby the Commodities of one Nation may be tranſported to another, the moſt beneficial Part of Trade would be inſignificant and unprofitable, and many Parts of the World would be barbarous and ſtrange to each other, did not the mutual Accommodations of Trade give them the neceſſary Occaſions to maintain ſuch amicable Correſpondencies in the way of Merchandize.

And to encourage ſo advantagious Ends, the Art and Knowledge of Navigation hath been a Subject of great Curioſity for many Ages, wherein much Labour and Study hath been imployed to make a Science ſo conducive to the Advancement of Trade, both practicable and eaſy, which is evident from the many Books that have been publiſhed for inſtructing Mariners in the Skill and Practice of Sailing, and from the variety of Inſtruments that have been invented for reſolving the ſeveral Queſtions in Trigonometry, *that are neceſſary to be underſtood in the Skill of Conducting a Ship from one Port or Place to another.*

So that, perhaps, it may ſeem ſtrange, that after ſo many Rules and Directions have been given by the moſt skilful Mathematicians, for teaching and inſtructing

ſtructing the ſeveral ways of Sailing, and which have been acquieſced in for a long ſeries of Time, that any other Method of Sailing ſhould be propoſed than what has received a general Approbation from Practice and Experience.

But ſince there have been Thoughts that have had their critical Times of being regarded, which have eſcaped the Obſervation even of judicious Men, and for that ſome things propoſed in this Treatiſe are not only New, but of Conſequence to be underſtood for the improvement of Navigation, whereby the Solution of all the difficult Problems in Sailing may be rendred eaſy and practicable, without the uſe of any Logarithmical Tables of Sines, Tangents, and Secants, or Tables of Meridional-Parts, or of the difference of Latitude and Departure, I have preſumed to offer my Sentiments on this Subject, for the benefit of the Publick.

Plain-Sailing is declared to be erronious; and tho' Mercator's *Sailing is accounted a true way of Sailing, yet it is found by Experience, that the generality of Mariners finding* Mercator's *Sailing too hard for them to Practiſe; they perform all their Voyages according to Plain-Sailing, and run the hazard of all the Dangers and Errors they may be expoſed to thereby.*

But ſince Sailing by the Arch of a great Circle is eſteemed the moſt exact Way, I ſhall endeavour to demonſtrate, that it is the moſt plain and certain Way, and eaſieſt to be underſtood and put in practice.

I am ſenſible I ſhall be oppoſed in this Undertaking, by ſome who will hardly be induced to approve of any thing that is not the reſult of their own Speculations.

By others, who being concern'd in the Profit and Advantage of Teaching the difficult Methods of Navigation by the nice Rules and Operations of Trigonometry, *will find it to interfere with their Intereſts, to have the ſame Inſtrumentally performed, and thereby made Intelligible and Plain to the meaneſt Capacities: And I believe this Way will be no leſs ſlighted and neglected by thoſe who by long Cuſtom and Uſage have been habituated to the Way of Plain-Sailing, and that they will think themſelves too Wiſe to be taught a new Leſſon, and by a tenacious adhering to what they have had a long and continued Experience of, will become like ſome* Iriſhmen *heretofore, whom no Arguments could prevail upon to alter the Cuſtom of drawing the Plow by their Horſes Tails, becauſe their Great-Great-Grand-*

fathers

fathers never knew any other Methods.

But I ſhall not be concern'd for any Cenſure that may be beſtowed on me from ſuch Prejudices; yet it is not without Regret that I have undertaken this Task, who cannot pretend to any Skill in the Mathematicks, nor ever had the leaſt Experience in Navigation.

However, I have uſed my utmoſt Induſtry to be well aſſured in the Truth and Certainty of what I have adventured to repreſent in the enſuing Diſcourſe, and ſhall refer my ſelf to Time and Experience to allow or diſallow of what I have devoted with the greateſt Sincerity of Intention to the publick Service of the Nation.

A DISCOURSE OF NAVIGATION.

THE Qualifications of a skilful Sailor conſiſt in the right Knowledge how to Sail and Work a Ship with ſafety in reſpect to Wind and Weather; and how to make allowance for Currents, Lee-way, and Variation of the Compaſs, which is beſt attained to by Practice and Experience; tho' ſeveral uſeful Rules might be laid down, that would be of advantage to the Sailor.

The other Part of his Knowledge, is how to Conduct his Ship from one Port or Place to another, by underſtanding how to direct a Ship's Courſe, and compute the Ship's Way from time to time, as occaſion may require, to the end that he may be capable throughout his Voyage to know the Latitudes and Longitudes of his ſeveral Stations at Sea, which is only to be attained to by Rules and Inſtructions deduced from Principles Mathematical.

Wherefore the ſubject Matter of this Diſcourſe, is to lay down ſuch Rules and Methods to be obſerved in Sailing as may ſufficiently inſtruct the Mariner in the performance of his Duty relating to the mathematical Part of Navigation.

And to this end it is requiſite that every Sailor ſhould have a true Idea of the Globe of the Earth and Water, which is a compleat ſphærical Body, whereon all the Lines that may be ſuppoſed to be drawn, will be ſphærical.

Secondly, That the Globe having two Places aſcertain'd thereon, called the

North and *South* Poles; every other Place is diſtinguiſhed from them in their reſpective Hæmiſpheres, by the ſeveral Circles of Latitude ſuppoſed to be drawn round the Globe in ſeveral Parallels from the Æquator up to each Pole, and by the ſeveral Circles of Longitude ſuppoſed to be drawn through each Pole, ſo as to interſect the Æquator and all the Parallels of Latitude in each Hæmiſphere at right Angles: And the Difference of each Latitude being diſtinguiſhed by Degrees and Minutes reckoned on the Circles of Longitude, and the Difference of each Longitude being diſtinguiſhed by Degrees and Minutes reckoned on the Æquator or middle Circle of Latitude between the two Hæmiſpheres; every Place that is ſo interſected at right Angles, is ſaid to be in ſuch a Latitude, and ſuch a Longitude from the *North* or *South* Pole.

Thirdly, That every Place thus diſtinguiſhed from the Poles by Latitudes and Longitudes, may be diſtinguiſhed from any other Place on the Globe by

Azimuths and Almicanthars, which are no other than the *like* ſort of Circles that may be ſuppoſed to be drawn on the Globe, in imitation of Latitudes and Longitudes, and may be divided in like manner. (that is to ſay) The Azimuth Circles are ſuppoſed to be drawn through the Zenith and Nadir of ſuch firſt Place, and the Almicanthar-Circles are ſuppoſed to be drawn in Parallels from the Horizon (which equally divideth the Zenith and Nadir, as the Æquator doth the Poles) to the Zenith and Nadir reſpectively; which Azimuths and Almicanthars, interſecting each other at right Angles in a Point, do thereby determine the Situation and Diſtance of the firſt from the ſecond Place.

Fourthly, That the Circles of Longitude are not Parallels, but are drawn nearer to each other from the Æquator to each Pole, and ſo are the Azimuths drawn nearer to each other from the Horizon to the Zenith or Nadir, but the Latitudes are Parallels to each other from the Æquator to each Pole, and in like manner, the Almicanthars are Parallels to each other from the Horizon to the Zenith and Nadir.

Fifthly, That the Circles of Latitude are leſſer in Circumference as they are drawn nearer from the Æquator to each Pole, and ſo are the Almicanthar-Circles, as they are drawn nearer from the Horizon to the Zenith or Nadir.

The next Thing to be conſidered, is the Projection of the Sea-Charts, and the uſes that are made thereof in Sailing; whereof there are two different Sorts, one of them being called the *Plain-Chart*, and the other *Mercator's-Chart*, from whence there are accounted two different Ways of Sailing, becauſe they ſhew different Ways of reſolving the ſeveral Problems in Sailing; however, the Courſe that is ſteered is directed by the ſame Rhumb in both of them, and both the ſaid Charts are intended ſo far as the ſame are capable thereof, to repreſent the Terreſtrial Globe, and ſet all Places in their true Poſitions of Latitude and Longitude, and yet in Truth, neither of them can exactly repreſent a Globe in their true Situations and Diſtance of Places.

For on the *Plain-Chart*, all the Lines of Latitude and Longitude are made æqui-diſtant; which has this Defect, that the Longitude Lines are not rightly placed, becauſe from the Æquator to the Pole, they ought to be drawn gradually nearer to each other, till they centre in a Point at the Pole, and conſequently many Places are repreſented on the *Plain-Chart* to be at a much greater diſtance from each other than in reality they are on the Globe, and if they were to be meaſured by a Scale, according to the *Plain-Chart*, it would lead the Mariner into great Errors, for which reaſons, ſeveral of the Mathematick-Teachers, in the Books which they have ſet forth, relating to plain Sailing, ſay, That is notoriouſly erronious and dangerous, and that he who truſts to his *Plain-Chart* will be very much deceived, both in his Courſe, and in his Diſtance, unleſs it be in Places near the Æquator; and the reaſon is, becauſe there muſt be different Allowances for the Computations of the Longitudes, according to the different Latitudes that are Sailed in, without which Proviſion, the Sailor is ſure to be miſguided in caſting up of his Reckoning.

The ſame may be ſaid of *Mercator's-Chart*, That all the Lines of Longitude are æqui-diſtant; but that Defect is endeavoured to be ſupplied by an artificial Contrivance, of ſetting the Latitudes as much out of their true Places in one reſpect, as the Longitudes are in another, and thereby reconciling them to a *medium* of Truth from two Falſities.

However, let *Mercator's-Chart* be as true as ſome are pleaſed to ſuppoſe it, yet it muſt be admitted, that the Difficulties of Comprehending the Way of Sailing thereby, are ſuch, that moſt Sailors do reject the uſe of it, and govern themſelves, in their ſeveral Voyages, by plain Sailing, rather than puzzle themſelves with the Niceties of *Mercator's-Sailing*.

But ſtill there is a neceſſity of uſing ſome Sea Charts or other, to diſtinguiſh the Latitudes of Places on the Globe, whereby the Sailor may by his view of the Chart, comprehend the Poſitions of Places, and diſcern how near or diſtant they are from each other, or from any Coaſts, Iſlands, or Rocks.

Perhaps therefore, a *Polar-Chart* would be more uſeful for ſuch purpoſes, than either the *Plain* or *Mercator's-Chart*: For that the Pole being placed in the Centre of the Chart, all the Parts of the Hæmiſphere being extended from thence to the Æquator, and all the Latitudes and Longitudes being drawn thereon, according to the Form and Figure of the Globe, it gives a clearer Notion thereof, and repreſents the Poſition of Places more naturally and plainly than by any other Figure, and has this advantage, that it is capable of having an Index, whereon the Latitudes may be graduated, and being turned on the Centre to any Place, it will ſhew at one view the Latitude of the Place by the Graduations on the Index, and the Longitude of the Place, by the Poſition of the Index on the Degrees of the Æquator.

A Third Thing to be conſidered, is the different Way of Sailing, by the *Rhumb*, and by the *Azimuth*, commonly called Sailing by the Arch of a great Circle; to which end I ſhall make ſome Obſervations on the difference between them, and leave it to the Mariners Choice to make uſe of one Way or the other at his Pleaſure.

Now the *Rhumb* is that Point of the Compaſs, which being ſteered by, the Ship will be continued in ſuch a Courſe, as without altering the ſame, will bring her from the Place of her Departure, to the Place of her intended Arrival, and makes equal Angles with all the Meridians through which it paſſes, though it does not make a direct, but round-about Courſe, and differs from the direct Courſe, as the Bow does from the String, or as a random Shot from a Level, where the Aim muſt be taken above the Mark, leſt the Tendency of the Weight ſhould bring the Arrow, or Bullet, below the Mark, before it arrives at the Mark.

For in Sailing, the Magnetick-Needle in every different Place that is not in the ſame Meridian, has a different Aſpect to the Pole, and the Compaſs will be in a different Poſition in every different Place, and unleſs there be an allowance given in ſetting out more to the South-ward, than the direct Courſe requires, the Ship will be inſenſibly carried in a Spiral manner, more to the Norrh-ward than it ſhould be.

But the *Azimuth* is that Point of the Compaſs which bears in a direct Line from the one Place to the other, and is agreed to be the exacteſt Way of Sailing, for ſuch as know how to keep to it, and therefore the Diſeaſe being known, I mean the different Aſpect to the Pole, in every different Place, the Remedy is eaſy to be applyed: For in Sailing Four and twenty Hours, the Compaſs will not in any Caſe change towards the North, above one Degree; and if the Mariner does but make that ſmall allowance once a Day, as occaſion ſhall require, he ſhall be able to keep as exactly to the Courſe of the *Azimuth*, as he may, in the other caſe, to the Courſe of the *Rhumb*: In the firſt Place, one allowance is made for the whole Voyage: In the ſecond Caſe, the allowance is repeated once in Twenty four Hours, and has not the leaſt Difficulty or Uncertainty in the Practice and Performance thereof.

The Fourth Thing to be conſidered, and which is the moſt Material to be rightly underſtood, is to know the uſe of Triangles, and the reaſon wherein they are ſo ſerviceable in the Practice of Navigation.

Now in Sailing there are two Queſtions needful to be reſolved on all occaſions, throughout the whole Courſe of a Voyage.

One is, where the Latitude and Longitude of two Places are given, What is the Courſe and Diſtance from the firſt Place to the ſecond Place?

The

The other is, where the Courſe and Diſtance are given, What is the Latitude and Longitude of the Place arrived to?

Which Queſtions cannot be determined, but by the uſe of Triangles, that is, by aſſigning three certain Points, from whence three Lines being ſo drawn, that each Line may touch two of the Points, thereby every Point will be touched by two Lines, by which means, every Triangle will be compleatly formed, and from a Triangle being thus formed, the Queſtions propounded may be reſolved, by finding the Contents of the Angles, and the Extents of the Sides, as if a Ship were to depart from the *Lizard*, in the Latitude of 50°; 10 and in the Longitude of 15°; 00 to the *Bermudas*, in the Latitude of 32°; 30, and in the Longitude of 318°; 00. In this Caſe, the Latitudes and Longitudes being given, the Queſtion is, What Point of the Compaſs the Mariner muſt Steer by, to conduct his Ship the direct Way from the *Lizard* to the *Bermudas*? Which may be done by forming either an Oblique or Right-Angle-Triangle, according to the different Points that may be aſſigned.

In the Oblique-Triangle, the firſt Point may be at the Pole, the ſecond Point at the *Lizard*, and the third Point at the *Bermudas*. The firſt Point at the Pole, is made an Angle, by being contained between the two Meridians. The ſecond Point at the *Lizard*, is made an Angle, by being contained between the Arch of the Meridian that touches the *Lizard* and the Pole, and between the Arch of the Azimuth, that touches the *Lizard* and *Bermudas*. The Third Point at *Bermudas*, is made an Angle, by being contained between the Arch of the Meridian that touches the *Bermudas* from the Pole, and between the Arch of the Azimuth that touches the *Bermudas* from the *Lizard*. So that this Triangle when reſolved, by finding the Contents of the Angles, and Extent of the Sides, the Angle of the Azimuth at the *Lizard*, ſhews the Courſe, and the Extent of the Arch of the Azimuth, ſheweth the Diſtance.

But in the Right Angle-Triangles, the firſt Point muſt be at the *Lizard*, the ſecond Point at the *Bermudas*, and the third Point at the Arch of the Meridian of the *Lizard*, that is interſected by the Latitude of the *Bermudas*. The firſt Point at the *Lizard* becomes an Angle, by being contained between the ſame Arch of the Azimuth, that extends from the *Lizard* to the *Bermudas*, and the Arch of the Meridian that extends from the *Lizard* to the third Point, at the difference of the Latitude: And the ſecond Point at the *Bermudas*, becomes an Angle, by being contained between the ſame Arch of the Azimuth, that touches the ſecond Point, and the firſt Point. The Arch of the Latitude that touches the ſecond and third Point: And then the third Point becomes an Angle, by being contained between the ſame Arch of the Latitude that touches the third Point and the ſecond Point, and between the Arch of the Meridian that touches the third Point and the firſt Point.

Now the way of reſolving theſe Triangles, ſo as to find out the Content of the Angles, and the Extent of the Sides, is to be performed either Arithmetically, or Inſtrumentally.

The Arithmetical Performance thereof, is a Work of Nicety and Learning, wherein I ſhall not preſume to intermeddle, that Skill having been already taught in variety of Books, by learned Authors.

But having invented two INSTRUMENTS, for reſolving all Triangles by a plain and eaſy Way or Method that may be put in practice by every Mariner.

I ſhall firſt give a ſhort Deſcription of them, and then ſhew the ſeveral uſes of them in the Practice of Navigation.

The firſt INSTRUMENT is called,

A SPHÆRICAL-QUADRANT, *becauſe all its Operations are Sphærical, and all its Dimenſions are meaſured by the Arch of a Quadrant.*

THis Inſtrument is compoſed of three Quadrants of equal Dimenſions, whereof each Radius is two Foot more or leſs at diſcretion, the Arches of each Quadrant being divided by 90 Degrees, and each Degree by ſix Parts, containing ten Minutes each.

One of which Quadrants lieth Horizontally, and is the Baſis to the whole Inſtrument, repreſenting a fourth Part of the Æquator.

The two other Quadrants are ſo placed, that one Edge of each Quadrant lieth on the lower Quadrant, from the Centre to the Arch thereof, all three of them joining in a Point, and repreſenting the Centre of the Earth, and meaſure the ſemi-diameter of the Globe, from the Centre thereof, to the Æquator. The other Edges of the two Quadrants ſtand perpendicular, and meaſure the ſemi-diameter of the Axis, from the Centre of the Earth to the Pole, and all three of them being thus placed, repreſent a quarter Part of the Hæmiſphere.

Theſe two Quadrants thus perpendicularly placed, are ſo made to turn on the Axis, that they may be ſet to or from each other, at any diſtance, on the Arch of the lower Quadrant, and repreſent any two Meridians; on the Arches whereof, the Latitudes are diſtinguiſhed by Degrees and Minutes, as the Longitudes are upon the Arch of the lower Quadrant.

There is alſo a Semi-circle made on a thin Braſs-Plate, about four Inches Diameter, which is divided by twice 90 Degrees, beginning from each end of the Semi-circle, repreſenting one half of the Compaſs, from *North* to *South*, and is a Parallel to the Horizon.

Which Semi-circle is ſo made to ſlide on the Arches of either of the Meridians, that the Centre thereof may be ſet to any Latitude required, and repreſents the Zenith.

There is likewiſe an Arch of a Quadrant of the ſame dimenſions with the other Arches, and divided by Degrees and Minutes in the ſame manner, and repreſents the fourth Part of the Azimuth, or vertical Circle, which paſſes through the Zenith and the Nadir, which Arch is moved at the upper end thereof, on the Center-Pin of the Semi-circle, having a ſmall Index fixed thereto, about two Inches long, which ſhews upon the Degrees of the Semi-circle, how the Azimuth-Arch is to be moved, to repreſent the bearing from one Place to another, by the Degree that will be cut on the Azimuth-Arch, to ſhew the diſtance between them.

From which five Quadrants thus compoſed into one Inſtrument, to make it anſwer the Form of a Globe, it is applicable to ſeveral uſes and purpoſes of Navigation.

More particularly, to reſolve this neceſſary Queſtion, *viz.* both Latitudes and Longitudes being given, What is the Courſe and Diſtance? (that is) What Point of the Compaſs is to be Steered by, that may direct a Ship from one Place to another? and, How many Degrees and Minutes thoſe two Places are different from each other?

Which Queſtion is reſolved in this manner. The two Meridians are moved from each other, and ſet at the difference of Longitude between the two Places, whereby each Place hath its proper Meridian aſſigned; then the Braſs Semicircle is ſet on the Arch of the firſt Meridian, at the Latitude of the firſt Place, and the Arch of the Azimuth being ſet on the Pin of the Semi-circle and turned to the Latitude of the ſecond Place, the Index of the Azimuth will be thereby turned on the Semi-circle, to the very Degree of the Compaſs that is to be Steered by, and the Degrees and Minutes on the Arch of the Azimuth, between the firſt and ſecond Place will ſhew the Diſtance between the two Places.

And at the ſame time, the Triangle requiſite for the Solution of this Queſtion, is ſo formed and reſolved, that the meaneſt Capacity may eaſily comprehend the reaſon of it.

For the Angle at the Pole being the firſt Place is known by the difference of Longitude, the Angle at the ſecond Place is known by the Index, and on the Semi-circle and the Angle of the third Place, is the Compliment of 180 Degrees; and the Extent of the Sides are known by the Degree and Minutes on the two Arches of the Meridians, between the Pole and each Place, and by the Degrees and Minutes on the Arch of the Azimuth between the two Places.

'Tis true, the Degrees on this Inſtrument will not admit of above ſix Diviſions, and conſequently, the Diſtance cannot be ſhewn nearer than 10 Minutes, which, nevertheleſs, is ſufficient to anſwer the Queſtion of the Courſe and Diſtance, for no Mariner pretends to Steer nearer than two or three Degrees of the true Courſe; and therefore the Direction by this Inſtrument will be nearer than he is able to keep to by his Steerage.

But in caſting up the Reckoning of the Ship's Way every 24 Hours, it is requiſite that the Courſe and Diſtance, and the Difference of Latitude and Departure ſhould be computed to a Minute, which is performed by the Inſtrument called the CALCULATOR, being contrived to reſolve all plain Triangles, not exceeding the diſtance of two or three Degrees as the *Sphærical-Quadrant* reſolves all ſphærical Triangles not exceeding the diſtance of Ninety Degrees.

And firſt I will give you a Deſcription thereof, and then ſhew the Uſe to which it is applicable.

A Deſcription of the CALCULATOR.

IT's compoſed of a Piece of thin Braſs, 12 Inches long, and about 2 Inches broad; on the Sides whereof, in length are graduated 120 equal Parts from the Middle thereof both ways, and may be ſuppoſed the Meridian-Line, and from the Middle of the ſaid Scale, from one Side thereof is drawn a Semi-circle, extending to the other Side thereof; on the Circumference whereof is graduated twice 90 Degrees, beginning at each end of the Semi-circle, and likewiſe in a leſſer Circumference, juſt under the Degrees, are drawn the Points and Quarter-Points of the Compaſs, in each Quadrant of the Semi-circle. And this Piece may be called the *Latitude-Scale*, becauſe thereby the difference of Latitude is computed.

There is another Piece of thin Braſs, whereon are graduated 120 equal Parts, which hath a Centre at the beginning of the equal Parts, and is made to move on a Pin, at the Centre of the Semi-circle, and hath an Index that moves on the Semi-circle to any Degrees on the Quadrant, and may be called the *Diſtance-Scale*, for thereby is found the Diſtance that is run.

There is a third Piece of thin Braſs, graduated in like manner, by 120 equal Parts, which is made to ſlide on the *Latitude-Scale*, and on the *Diſtance-Scale*, ſo as to make one ſide of a Triangle, by cutting the Diſtance and the Latitude arrived to on each of the Scales.

The uſe hereof, is to caſt up the Reckoning in theſe three Caſes.

Firſt, If Courſe and Diſtance be given, to find the difference of Latitude and Departure.

Set the *Diſtance-Scale* on the Pin of the Semi-circle, and turn it till the Index reſts on the Courſe, then ſlide the Departure-Scale at a right Angle on the Latitude-Scale, till the Departure-Scale cuts the Diſtance-Scale at the diſtance given, and then the equal Parts on each Scale will ſhew the difference of Latitude on the *Latitude-Scale*, and the difference of Meridians in Minutes on the *Departure-Scale*, each equal Part being accounted a Minute.

Secondly, If Courſe and Latitude, by Obſervation, be given, to find the Diſtance and Departure, ſet the Departure-Scale on the Latitude-Scale, at a right Angle to the Latitude, by Obſervation, then ſet the Diſtance-Scale, ſo as the Index may touch the Courſe given, then will the Diſtance-Scale be cut by the Departure-Scale at the Diſtance required, and the Departure-Scale be cut by the Diſtance-Scale, at the Departure required.

Thirdly, If Diſtance and Latitude, by Obſervation, be given, to find the Courſe and Departure.

Set the Departure-Scale at a right Angle on the Latitude-Scale, to the Latitude by Obſervation; then ſet the Diſtance-Scale to the Departure-Scale, till they cut each other at the Diſtance given, then will the Index of the Diſtance-Scale, ſhew the Courſe on the Semi-circle; and the Departure-Scale will be cut by the Diſtance-Scale, at the Departure required.

Now the Triangle is the ſame in all three Caſes, and being a right Angle-Triangle is formed thus, the firſt Angle is at the Place of Departure, the ſecond Angle is at the Difference of Latitude, and the third Angle is at the Place arrived to: And the Content of the firſt Angle is known by the Index on the Semi-circle; the ſecond Angle being a right Angle, is known to be 90 Degrees; and the third Angle is the Compliment of 90 with the firſt, and the Extents of the Sides are ſhewn of courſe, by the equal Parts on each Scale.

Only it remains when the difference of Latitude and Departure are found to aſcertain the Longitude by the Departure, and is found by a ſhort and eaſy Table of the ſeveral Minutes that are proportional in every Latitude to 60 Minutes on the Æquator.

As if the Departure were 107 Minutes in the Latitude of 45 Degrees; the Table will ſhew, that 42 Minutes in that Latitude are proportional to 60 Minutes in the Æquator.

Now 42 is twice in 107, which makes 84, and that gives two Degrees; then take 84 out of 107, and the remainder is 23, which is the half of 42, and 2 over, therefore the half of 42 being 21, gives half a Degree more, and then the remaining 2 Minutes will give about 2 Minutes more; ſo that the difference of Longitude might be reckoned at 2 Degrees, and about 32 Minutes: Whereas reckoning by the *Plain-Chart*, where the Longitude Lines are Parallels, the difference of Longitude would be ſuppoſed to be but one Degree and 47 Minutes, which would be a Miſtake of 49 Minutes, in 24 Hours Sailing.

To ſum up therefore all that is hereby propoſed in a few Inſtances.

Let it be ſuppoſed, That a Ship were bound from one Port to another.

The Mariner is firſt to conſider the Latitude and Longitude of the Port he is to Sail from, and then the Latitude and Longitude of the Port he is to Sail to, which he is to find out by ſome Chart.

Secondly, He is to find out the Azimuth, which beareth directly from the firſt to the ſecond Port, whereby to know the Point of his Compaſs he is to Steer by, and this is ſhewn by the *SPHÆRICAL-QUADRANT*, as before is mentioned, together with the diſtance between the two Places from the Degrees and Minutes graduated on the Arch of the Azimuth.

Thirdly, When he hath ſailed 24 Hours more or leſs, and is to caſt up the Reckoning of the Ship's Way, he will have his Courſe and Diſtance given him on the Log-board; and then by the *CALCULATOR* he may find his difference of Latitude and Departure, by the

Rule directed in the uſe of the *CALCULATOR*.

Fourthly, By the Table of Minutes, that in each Latitude are proportional to 60 Minutes on the Æquator, he may find the difference of Longitude by the difference of Departure.

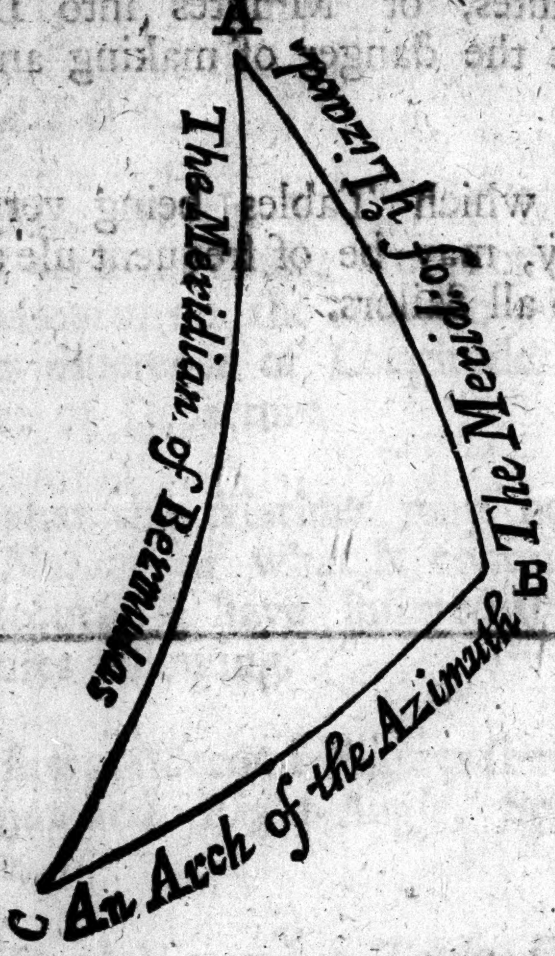
And that the Mariner may have the clearer Notion of what is contained in this Diſcourſe, I have inſerted the ſeveral Figures following.

The firſt and ſecond Figures ſhew both an Oblique and Right-Angle, Sphærical Triangle.

The Third Figure is a Table, ſhewing how many Minutes in each Latitude are proportional to ſixty Minutes in the Æquator, for finding the difference of Longitude by the difference of Departure.

The Fourth Figure is a Table, ſhewing how many Minutes are contained in every Degree of Latitude, for turning Degrees into to Minutes, or Minutes into Degrees, without the danger of making any Miſtake.

Both which Tables being very ſhort and eaſy, may be of frequent uſe and Benefit to all Sailors.



The Explanation and Vſe of the firſt Figure, being an oblique Sphærical-Triangle.

A. Is the Angle at the Pole. *B.* is the Angle at the *Lizard.* C. is the Angle at the *Bermudas.*

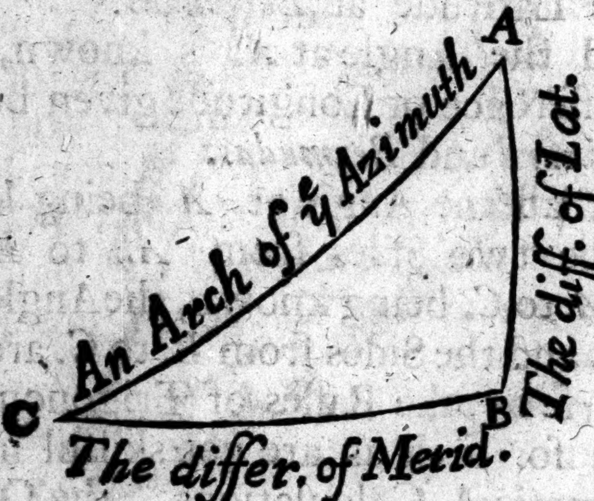
The Side from *A.* to *B.* is an Arch of the Meridian from the Pole to the *Lizard*, and is known to be 40 Degrees, being the compliment of 90 Degrees from 50 Degrees, the Latitude of the *Lizard*.

The Side from *A.* to *C.* is an Arch of the Meridian, from the Pole to the *Bermudas*, and is known to be 58 Degrees by the ſame Rule, being the compliment of the Latitude at *Bermudas*.

And the Angle at *A.* is known, being the difference of Longitude given between the *Lizard* and *Bermudas*.

So that the Angle at *A.* being known, and the two Sides from *A.* to *B.* and from *A.* to *C.* being known, the Angles at *B.* and *C.* and the Sides from *B.* to *C.* are found of courſe by the Rules of Trigonometry.

But for ſuch as are not skilful in thoſe Arithmetical Calculations, the Queſtion is eaſy to be reſolved by the *SPHÆRICAL-QVADRANT*, only by ſeting the two Meridians aſunder, accordin to the difference of Longitude given, an ſetting the Semicircle on the Meridian a the Latitude of the *Lizard*, and ſettin the Azimuth-Arch on the Pin of the Semicircle, and moving the Azimuth on the Meridian of the *Bermudas*, till it touches the Latitude given: Then will the Index of the Azimuth, ſhew the Courſe on the Semicircle, and ſhew the Diſtance by the Degrees on the Azimuth; and exactly repreſent the firſt Figure.



The Explanation of the ſecond Figure, being a right Angle Sphærical-Triangle.

A. Is the Angle at the *Lizard.* B. is the Angle at the difference of Latitude between the *Bermudas* and the *Lizard,*

Lizard. C. is the Angle at the *Bermudas.*

This Triangle is reſolved both Arithmetically and Inſtrumentally, by the ſame Rules reſpectively, as are mentioned concerning the former Triangle.

And the uſe of both theſe Triangles is to reſolve this Queſtion, *viz.* both Latitudes and Longitudes being given, What is the Courſe and Diſtance? Which is performed by finding the Angle of the Azimuth to ſhew the Courſe, and the Extent of the Arch of the Azimuth to ſhew the Diſtance. In the firſt Figure, the Arch of the Azimuth is the Baſe of the Triangle, in the ſecond Figure it is the Hypothenuſe.

But if the Queſtion be, What is the Latitude and Longitude arrived to, where the Courſe and Diſtance is given?

In this caſe, if the Difference be more than three or four Degrees, it is beſt reſolved by the *Sphærical-Quadrant*; but if it be leſs than three Degrees, it may be reſolved to a Minute by the *Calculator*, which will ſhew the difference of Latitude,

tude, and difference of Meridian, by forming a plain right Angle-Triangle.

Only in regard that in every Parallel of Latitude, the Meridians are nearer and nearer to each other from the Æquator to the Pole.

This third Figure contains a TABLE of the Miles or Minutes in every ſeveral Latitude that are proportional to every 60 Miles or Minutes in the Æquator.

A TABLE of Minutes and Seconds, that in the Parallel of every different Degree of Latitude, are equal to 60 Minutes in the Æquator.

1			2			3		
D	*M*	*S*	*D*	*M*	*S*	*D*	*M*	*S*
1	59	59	31	51	26	61	29	5
2	59	58	32	50	53	62	28	10
3	59	53	33	50	19	63	27	14
4	59	51	34	45	45	63	26	18
5	59	46	35	49	9	65	25	21
6	59	40	36	48	32	66	24	24
7	59	33	37	47	55	67	23	27
8	59	25	38	47	17	68	22	29
9	59	16	39	46	38	69	21	30
10	59	5	40	45	58	70	20	31
11	58	54	41	45	17	71	19	32
12	58	41	42	44	35	72	18	32
13	58	28	43	43	53	73	17	32
14	58	13	44	43	10	74	16	32
15	57	57	45	42	26	75	15	32
16	57	41	46	41	41	76	14	31
17	57	23	47	40	55	77	13	30
18	57	4	48	40	9	78	12	28
19	56	44	49	39	22	79	11	27
20	56	23	50	38	34	80	10	25
21	56	1	51	37	46	81	9	23
22	55	38	52	36	56	82	8	21
23	55	14	53	36	7	83	7	19
24	54	49	54	35	16	84	6	16
25	54	23	55	34	25	85	5	14
26	53	56	56	33	32	86	4	11
27	53	28	57	32	41	87	3	8
28	52	59	58	31	48	88	2	5
29	52	29	59	31	54	89	1	3
30	51	58	60	30	0	90	0	0

For Example.

A Ship hath ſailed *S. W.* 127m. from the Latitude of 50 Degrees, and by a plain right Angle-Triangle, reſolved by the *Calculator*, the difference of Latitude is found to be 90 Minutes, which makes the Latitude arrived to 48 Degrees, 30 Minutes, and the difference of Meridian is found to be 90 Minutes; now it appears by this Table, that 40 Minutes in the Latitude of 48 Degrees, is proportional to 60 Minutes in the Æquator; now 2 times 40 Minutes makes 80 Minutes, and is equal to two Degrees in the Æquator; then there remains 10 Minutes of the 90 Minutes, which is the fourth Part of 40 Minutes, and is proportional to the fourth Part of 60 Minutes, which makes 15 Minutes, ſo that 90 Minutes in the Departure, in the Latitude of 48 Degrees, makes 2 Degrees 15 Minutes in the Æquator, which is the Longitude required.

The fourth Figure or Table, is a Computation of the Minutes that are contained in the ſeveral Degrees of Latitude; which is no more than turning Degrees into Minutes by Multiplication, or Minutes into Degrees by Diviſion. But becauſe Miſtakes may happen in thoſe Computations, it may be of uſe to have a Table truly caſt up, to prevent ſuch Errors, as often follow thoſe Miſtakes.

A TABLE of the ſeveral Minutes contained in *each* ſeveral Degree of Latitude from the Æqua. to the Pole.

1	0060	31	1860	61	3660
2	0120	32	1920	62	3720
3	0180	33	1980	63	3780
4	0240	34	2040	64	3840
5	0300	35	2100	65	3900
6	0360	36	2160	66	3960
7	0420	37	2220	67	4020
8	0480	38	2280	68	4080
9	0540	39	2340	69	4140
10	0600	40	2400	70	4200
11	0660	41	2460	71	4260
12	0720	42	2520	72	4320
13	0780	43	2580	73	4380
14	0840	44	2640	74	4440
15	0900	45	2700	75	4500
16	0960	46	2760	76	4560
17	1020	47	2820	77	4620
18	1080	48	2880	78	4680
19	1140	49	2940	79	4740
20	1200	50	3000	80	4800
21	1260	51	3060	81	4860
22	1320	52	3120	82	4920
23	1380	53	3180	83	4980
24	1440	54	3240	84	5040
25	1500	55	3300	85	5100
26	1560	56	3360	86	5160
27	1620	57	3420	87	5220
28	1680	58	3480	88	5280
29	1740	59	3540	89	5340
30	1800	60	3600	90	5400

There are ſeveral other uſes to which the *Spharical-Quadrant* is applicable, not only at Sea, but likewiſe at Land, for divers purpoſes, that are of conſequence to be known.

Firſt, For finding out the Meridian in any Place, either at Sea or at Land, not only at ſeveral times of the Day, but at ſeveral times in the Night.

Secondly, It will ſhew the Hour of the Day or Night to a Minute.

Thirdly, It will ſhew the Latitude of any Place, without any knowledge of the Sun's Declination.

Which Particulars are of conſequence to be known at Sea, becauſe the Meridian being known, the Variation of the Compaſs may be examined and adjuſted, and the miſtake of the Courſe thereby rectified, which muſt needs be of very great advantage to all Sailors.

It is likewiſe of conſequence to know the Hour and Minute of the Day and Night, for comparing the time with all Watches and Clocks: For that they may ſometimes be of very good uſe to rectifie miſtakes in the Computation of the Longitude, upon the caſting up of a Reckoning, and keeping a juſt account of the ſeveral Stations which a Ship makes in her Voyage.

In like manner, it is of conſequence to know the Meridian at Land ; and likewiſe the Latitudes of all Places at Land, in ſeveral Particulars, and for ſeveral Purpoſes, either of Neceſſity or Curioſity.

There is yet a farther uſe to be made of this Inſtrument, for thereby the meridional Diſtances of one Place from another may be known to half a Degree or leſs ; which I ſuppoſe to be that Secret, the World has been ſo long in ſearch of, for finding out the Longitude, in order to rectify the Terreſtrial Globe, and all ſuch Sea-Charts, as may be projected for the benefit of Navigation.

But I do not think it proper to make any further Diſcoveries on this Subject, till what I have already preſented for the publick Benefit, may receive a ſuitable Acceptation and Incouragement.

FINIS.